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# STABILITY AND SURGICAL COMPLICATIONS OF TOOTH-BORNE AND BONE-BORNE EXPANSION APPLIANCES IN SURGICAL ASSISTED RAPID MAXILLARY EXPANSION. A SYSTEMATIC REVIEW

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# Stability and Surgical Complications of Tooth-Borne and Bone-Borne Expansion Appliances in Surgical Assisted Rapid Maxillary Expansion. A Systematic Review

Dissertação apresentada como parte dos requisitos obrigatórios para a obtenção do título de Mestre, na área de Cirurgia e Traumatologia Bucomaxilofacial, pelo Programa de Pós-Graduação em Odontologia da Escola de Ciências da Saúde da Pontifícia Universidade Católica do Rio Grande do Sul.

**Orientador: Prof. Dr. Rogério Miranda Pagnoncelli**

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## Dedicatória

Dedico este trabalho a Deus e a minha família.

*“…, para Deus todas as coisas são possíveis”. Mateus 19:26.*

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## RESUMO

Os objetivos do presente estudo foram através de uma revisão sistemática, avaliar a estabilidade e as complicações cirúrgicas dos dispositivos de ancoragem esquelética, dentária ou híbrida na expansão rápida da maxila assistida cirurgicamente (SARME pelas siglas em inglês), bem como identificar o tipo de dispositivo de distração que melhor otimiza os procedimentos de SARME, estabelecendo uma hierarquia de estabilidade. Ademais, pretendeu-se avaliar a qualidade de literatura científica disponível sobre o assunto. A busca principal sistemática na literatura foi realizada através das bases de dados de PubMed, Embase, Cochrane Library e SciELO. Realizou-se, também, uma busca da literatura cinza no Google Acadêmico. Depois da leitura íntegra e do processo de elegibilidade, realizou-se uma busca manual nos artigos selecionados, fez-se a recolecção dos dados e a análise de qualidade dos mesmos. Chegou-se num total de 269 artigos da busca principal e 249 artigos na literatura cinza, sendo selecionados 47 artigos para a elegibilidade ($\kappa$=0.854). Após a mesma, 17 artigos foram incluídos ($\kappa$=0.866) e adicionaram-se 6 artigos da busca manual. A estabilidade da largura foi demostrada pelos rangos de recidiva com porcentagens que oscilam nas medições dentárias dos dispositivos TB para caninos entre 4-35%, para pré-molares de 1-37% e nos molares de 0.2-49.5%. Para dispositivos BB encontrou-se recidivas para caninos de 1.7-21%, para pré-molares de 1.5% e molares de 4.6-11.5%. Para dispositivos HB a recidiva para os premolares foi de 14% e nos molares foi reportado um ganho de 1.8%. Para as medições esqueléticas, foram encontradas porcentagens similares de recidiva nos dispositivos TB e BB para o assoalho nasal, sendo que tiveram as maiores porcentagens de recidiva 11-53% (TB) e 41.6% (BB) comparadas com as medições esqueléticas da maxila tomadas num sentido mais cranial de 18% de recidiva e até 10% de ganho para TB e de 16% de recidiva para BB. As complicações mais comuns foram reabsorção óssea para os TB (18.14%) e as associadas ao dispositivo para os BB (17.9%). Os estudos apresentaram riscos de viés alto em 19 estudos, médio em 3 e baixo em um estudo. Os procedimentos de SARME foram considerados por terem alta estabilidade ao longo prazo, porém a recidiva esteve altamente influenciada pelos tratamentos ortodônticos durante os períodos de consolidação. Parece ser que os dispositivos BB tiveram as menores recidivas, porém não foram encontradas porcentagens de recidivas com diferenças significativas quando sometidos a ensaios clínicos randomizados. Precisam-se de mais estudos com desenhos com baixo risco de viés e maiores populações e variáveis homogêneas, para conseguir realizar estudos meta-analíticos e tomar assim melhores decisões baseadas em alta evidencia cientifica.


**Palavras chave: Revisão Sistemática. Expansão Maxilar. Estabilidade.**

## ABSTRACT

The main objectives of this study were to evaluate through a systematic review the stability and complications of tooth-borne (TB) and bone-borne (BB)/ Hybrid-borne (HB) appliances in surgically assisted rapid maxillary expansion (SARME), identifying the types of appliances that best optimize SARME procedures and to assess the quality of scientific literature available. The main search was carried out in PubMed, Embase, Cochrane Library and SciELO databases, a grey literature search through Google Scholar and a manual search of the articles included. Forty-seven articles were included in the eligibility process (46 articles of the main search and one article founded in the grey literature, $\kappa$=0.854). After the eligibility process (17 articles, $\kappa$=0.866) and the manual search (6 articles), 23 were finally included. Stability of TB appliances showed width relapse percentages that ranged in canines from 4-35%, in premolars from 1-37% and in the molars from 0.2-49.5%. For BB appliances, the width relapse percentages ranged in canines from 1.7-21%, in premolars of 1.5% and in molars from 4.6-11.5%. For HB appliances, the width relapse was of 14% for premolars and a gain of 1.8% of gain reported in the molar area. For skeletal measurements, similar relapse percentages were encountered in TB and BB appliances in the nasal floor (11-53% in TB and 41.6% in BB appliances) compared to the relapse percentages in the maxilla level (18% relapse and 10% of width gain in TB appliances and 16% of relapse in BB appliances). The most prevalent complications were bone resorption in TB appliances (18.14%) and in BB appliances were related to the appliance (17.9%). The studies presented high risk of bias in 19 studies, medium in 3 studies and low in one study. The TB and BB appliances in procedures of SARME were considered for having a high stability in the long-term, but the relapse encountered is highly influenced in the post-orthodontic treatments, where arc-form coordination is achieved in the consolidation periods. It seemed to be that BB appliances had lesser relapse than TB appliances, however, there were not encountered significant differences in the relapse percentages when compared both groups in randomized clinical trials. It is necessary to carry out studies with better methodological designs with low risks of bias, in order to have homogeneous variables and bigger samples, therefore meta-analytic studies could be performed and clinical high scientific based decisions made for achieving the best outcomes in SARME.


**Key words: Systematic review. Stability. Complications. SARME.**

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Borne Hyrax; TB-Hs: tooth-borne Haas; BB-t: Bone-Borne TPD (Transpalatal Distractor); BB-t/r: Bone-borne TPD/RPD(Rotterdam Palatal Distractor); BB-h: Hybrid Bone-borne ; TxC: treatment change. AM: anterior maxilla; PM: posterior maxilla. PA: Posterior-anterior. (&): data consulted to the author. NE: not evaluated; NI: not inform

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# LISTA DE ABREVIAÇÕES, ACRÔNIMOS E SÍMBOLOS

| | |
|---|---|
| SARME | Surgically Assisted Rapid Maxillary Expansion |
| SARPE | Surgically Assisted Rapid Palatal Expansion |
| PMD | Pterygoid-Maxillary Disjunction |
| DOI | Digital Object Identifier |
| EMBASE | Excerpta Medica dataBASE |
| SciELO | Scientific Electronic Library Online |
| TB | Tooth-Borne |
| BB | Bone-Borne |
| HB | Hybrid-Borne |
| LP | Latency Period |
| AR | Activation Rate |
| CP | Consolidation Period |
| CBCT | Cone Beam Computer Tomography |
| CT | Computer Tomography |
| PA | Posterior-Anterior |
| ICD | Inter-Canine dental width |
| ADA | Anterior Dental Width |
| PDA | Posterior Dental Width |
| ETOS | Expansion at Time of Surgery |
| MEMP | Mauricio Esteban Muñoz Pereira |
| LSM | Lucas da Silva Meirelles |
| RMP | Rogério Miranda Pagnoncelli |
| RBO | Rogério Belle de Oliveira |
| OLHJ | Orion Luiz Haas Junior |

| | |
|---|---|
| MeSH | Medical Subject Headings |
| RCT | Randomized Clinical Trial |
| PCS | Prospective Clinical Study |
| RCS | Retrospective Clinical Study |
| TB-h | Tooth-Borne Hyrax |
| TB-Hs | Tooth-Borne Haas |
| BB-t | Bone-Borne Transpalatal distractor |
| BB-t/r | Bone-Borne TPD-Rotterdam palatal distractor |
| NSAID | Non-Steroid Anti-Inflammatory Drugs |
| NI | Data not informed on the study |
| NE | Data Not Evaluated on the study |
| ° | degrees |
| * | Statistically Significant |
| & | Data consulted to the author |
| κ | Kappa test. |
| U.S.A. | United States of America |
| F | Feminine |
| M | Masculine |
| - | Loss of width |
| + | Gain of width |
| ≥ | Greater (than) or equal (to) |
| mm | Millimeters |

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# I Introdução

A expansão rápida de maxila cirurgicamente assistida, conhecida também por suas siglas em inglês como (SARME/SARPE), é um procedimento que forma parte da rotina do cirurgião bucomaxilofacial, sendo considerada para o tratamento das discrepâncias transversais em pacientes adultos esqueleticamente maduros[1].

A atresia maxilar é comumente associada tanto a pacientes não sindrômicos quanto sindrômicos, e sua correção pode ser feita através de SARME uni- ou bilateral, com osteotomias de tipo LeFort I associadas às osteotomias dos pilares principais do maciço-facial: zigomático-maxilar, sutura palatina média, e os processos pterigoides.[2]

Através da história, as técnicas de SARME hão sido modificadas para melhorar a estabilidade ao longo prazo, reduzir complicações e assim otimizar os resultados, porém não há consenso à respeito do tipo de dispositivo de expansão a serem utilizados, sejam dentários ou ósseos (TB ou BB pelas siglas em inglês, respectivamente), da existência, causas e quantidade de recidivas encontradas nos dispositivos de expansão, assim como das principais complicações associadas.[3]

Portanto, resulta imperativo e pertinente a elaboração de estudos com o mais alto nível de evidencia científica possível, de tal forma que possam tornar-se úteis na compreensão e identificação da estabilidade dos tratamentos de expansão maxilar, e assim proporcionar recomendações e/ou protocolos dos mesmos.

# II Objetivos

## 2.1 Objetivo geral

- Avaliar a estabilidade e as complicações associadas aos dispositivos TB, BB e HB nos procedimentos de SARME através de uma revisão sistemática.

## 2.1 Objetivos específicos

- Identificar qual protocolo e tipo de dispositivo de distração melhor otimiza os procedimentos de SARME
- Explicar a relação entre dispositivos TB e BB e seus efeitos esqueléticos e dentários.
- Avaliar a qualidade de literatura científica disponível e a necessidade de novos desenhos de estudo sobre o assunto.

# *Artigo*

# 1. Introduction

Transverse maxillary deficiency is common among orthodontic-surgical patients, presenting unilateral or bilateral crossbites, narrow palatal vault, dental crowding and other functional problems such as nasal resistance and impaired respiratory functions. Surgical assisted rapid maxillary/palatal expansion (SARME/SARPE) is the treatment of choice for many maxillofacial surgeons and orthodontists for adult patients with maxillary transverse deficiency. [1–5]

SARPE technique requires a surgical intervention to the bony buttresses performed by osteotomies in order to relief bony resistance. A LeFort I osteotomy with or without pterygomaxillary disjunction (PMD), a midpalatal suture disjunction[2,3,6] under general anesthesia, and the utilization of an oral palatal distractor with bone-borne (BB), tooth borne (TB) or hybrid borne anchorage appliances (HB, a combination of bone-tooth borne) are the most traditional. Most common protocols of maxillary distraction contemplate 5 to 7 days of latency period (LP), follow by twice-daily activations (0.5 mm/day) until desirable width is achieved. Then a 3 to 4-month period is required for consolidation[7].

Rapid maxillary expansion on adults can result in skeletal and dentoalveolar non-desirable complications, such as asymmetric expansion, root resorption, cortical fenestrations, dentoalveolar complex tipping, loss of anchorage and teeth extrusion.[8] Other atypical complications from expansion devices one can mention are epistaxis, palatal mucosal lacerations, aseptic pressure necrosis, infections, partial paralysis of the oculomotor nerve[8] and even carotid cavernous fistula.[9]

According to Koudstaal et al[10], relapse is defined as the gradual recurrence of the abnormality for which distraction was performed. Thus, relapse and stability has been an important concern when expanding the maxilla, and therefore is necessary the choice of the best appliance under specific indications. To date, there is no consensus regarding the surgical technique or type of maxillary distractor to be used in order to maximized expansion purposes and enhanced stability as well as one that reports the minimal unwanted side effects on the treatment of maxillary atresia[10-11].

Consequently, in order to assess stability and complication rates of the different types of distraction appliances in SARME, a systematic review can offer an important source for guidelines and clinical decision-making.

The present study evaluated the skeletal/dental width stability and the surgical complications related to TB, BB and HB appliances in SARME/SARPE procedures. This revision was conducted through two specific questions: (1) which type of distraction appliance provides the best stability in the post-operative period? And (2) What are the main surgical complications of the distraction devices in SARME procedures?

# 2 Methodology

A systematic literature search was conducted in PubMed, EMBASE, Cochrane Library and SciELO using the PICO strategy (population: dentofacial deformity or orthognathic surgery; intervention: SARME with TB appliance; C: maxillary expansion in SARME with BB and/or HB appliance; O: relapse and surgical complications in SARME). There were no restrictions in the search regarding language and year of publication. Key words and Boolean operators (OR, AND) were used for the combinations of thesaurus terms related to dentofacial deformity, anchorage appliances (TB, BB, HB) in SARME, relapse and surgical complications. It was also used individual key words corresponding to “tooth-borne” and “bone-borne”

## 2.1 Search Strategy

### 2.1.2 Main Search

PubMed search was carried out using MeSH terms( and their entry terms) and non-MeSH terms “tooth-borne”, “bone-borne” and “hybrid appliance” as follows: [(“Dentofacial deformities” OR “Deformities, Dentofacial” OR “Deformity, Dentofacial” OR “Dentofacial Deformity” OR “Dentofacial Abnormalities” OR “Abnormalities, Dentofacial” OR “Abnormality, Dentofacial” OR “Dentofacial Abnormality” OR “Dentofacial Dyplasia” OR “Dentofacial Dyplasias” OR “Dyplasia, Dentofacial” OR “Orthognathic Surgical Procedure” OR “Procedure, Orthognathic Surgical” OR “Procedures, Orthognathic Surgical” OR “Surgical Procedure, Orthognathic” OR “Surgical Procedures, Orthognathic” OR “Surgery,

Maxillofacial Orthognathic" OR "Surgeries, Maxillofacial Orthognathic" OR "Orthognathic Surgery, Maxillofacial" OR "Orthognathic Surgeries, Maxillofacial" OR "Maxillofacial Orthognathic Surgeries" OR "Maxillofacial Orthognathic Surgery") AND ("Expansion Technique, Palatal" OR "Expansion Techniques, Palatal" OR "Palatal Expansion Techniques" OR "Technique, Palatal Expansion" OR "Palatal Expansion Technic" OR "Expansion Technic, Palatal" OR "Expansion Technics, Palatal" OR "Palatal Expansion Technics" OR "Technic, Palatal Expansion" OR "Maxillary Expansion" OR "Expansion, Maxillary") ("Recurrences" OR "Recrudescences" OR "Recrudescence" OR "Relapse" OR "Relapses") OR ("Complication, Postoperative" OR "Complications, Postoperative" OR "Postoperative Complication" OR "associated disease" OR "coexistent conditions" OR "sequels" OR "concomitant disease" OR "sequelae" OR "associated conditions" OR "coexistent disease") AND ("tooth-borne") OR ("bone-borne")]

For EMBASE, the PICO strategy was employed, with the following Emtree terms: "dentofacial deformity"; "orthognathic surgery", "palatal expansion", "relapse", "stability", "recurrence" and "complications".

('Dentofacial deformity'/exp OR 'dentofacial deformities' OR 'dentofacial deformity' OR 'dentofacial malformation' OR 'orthognathic surgery'/exp OR 'orthognathic surgery' OR 'orthognathic surgical procedures') AND ('palatal expansion'/exp OR 'palatal expansion' OR 'palatal expansion procedure' OR 'palatal expansion technique' OR 'tooth-borne' OR 'bone-borne') AND ('recurrence risk'/exp OR 'recidivation risk' OR 'recidivism risk' OR 'recurrence rate' OR 'recurrence risk'

OR 'relapse rate' OR 'risk recidivism' OR 'risk, recurrence' OR 'complication'/exp OR 'complication, postoperative' OR 'complication, surgical' OR ‘post-operative complication’ OR ‘post-operative complications’ OR ‘postoperative complications’ OR ‘postsurgical complication’ OR ‘surgical complication’ OR 'stability'/syn)

The search from the Cochrane Library and SciELO was based on the PubMed query, without the entry terms: [(“dentofacial deformity” OR “orthognathic surgery”) AND (“Palatal Expansion”) AND (“Recurrence” OR “Postoperative Complications”) OR (“tooth-borne” or “bone-borne”)]

### 2.1.2 Grey Literature Search

It was done in order to increase the range of the study retrieval and to contemplate those studies published in non-indexed journals that were not retrieved by the main strategy search. Therefore, the following query was designed: (“Dentofacial deformity”) AND ("palatal expansion technique" OR “SARPE” OR “SARME”) AND (“transpalatal distractor” OR “bone-borne” OR “tooth borne”) AND ("recurrence" OR “relapse” OR “Complication, Postoperative” OR “Complication, Intraoperative” OR “complications”).

### 2.1.3 Manual Search

Once the main search and grey literature were complete, it was performed a copious manual-search to look for articles not included previously.

## 2.2 Study Selection

The author MEMP conducted the systematic search and two authors MEMP and LSM selected the studies independently based on the article title and abstract. For the studies to be included in the full-revision, it must have the following information: (1) Intervention studies that constituted retrospective or prospective clinical studies with human subjects (Randomized clinical trials, non-randomized control trials, case series with samples >10). (2) Studies who evaluated stability of SARPE/SARME and/or studies that reported postoperative complications from the utilization of TB, BB or HB appliances in patients who had undergone SARPE/SARME procedures. The exclusion criteria comprehended: (1) case reports, (2) technical notes, (3) in vitro studies and animal studies, (4) review reports, (5) studies that included craniofacial syndromic patients and (6) studies with follow-ups and/or retention periods lesser than 3 months for articles whose principal objective was stability/relapse.

Consequently, if there was a discrepancy between authors in the eligibility of an article, a consensus by other experienced authors were made. (OLHJ/RBO/RMP).

Studies for which the titles and abstracts were evaluated and that were accepted in the first selection process were submitted to an eligibility assessment. The Cohen's kappa coefficient (k) was applied in order to measure inter-rater agreement regarding title and abstract selection.

## 2.3 Study Eligibility

Two blinded authors, (MEMP) and (LSM), regarding title, abstract, authorship and origin of the article checked the eligibility of studies. Articles that were included in the study selection were analyzed for eligibility with a form to standardized the analysis of the eligibility process (appendix 1) evaluating the following: (1) the study research topic had to be of TB and/or BB/HB appliances in SARME. (2) studies had to present stability and width relapse measurements (3) studies had to report surgical complications rates regarding TB, BB or HB appliances. (4) studies had to be original and interventional.

If there was a discrepancy between authors in the eligibility of an article, three authors that are more experienced were consulted for discussion. (OLHJ/RBO/RMP). When an article was rejected based on eligibility criteria, a reason was specified.

When there was a doubt concerning methodology or results, the corresponding author was contacted via email to clarify it. The Cohen's kappa coefficient ($\kappa$) was applied to test inter-rater agreement.

## 2.4 Data Collection Process

The same two authors (MEMP and LSM) completed independently the data extraction from the included studies as follows: demographic data, methodological data, final dental and skeletal expansion and width relapse (stability outcomes) and

surgical complications of TB and BB devices. In case of discordance, three authors that are more experienced were consulted for discussion. (OLHJ/RBO/RMP).

### 2.4.1 Analysis of surgical stability

The analysis of stability was assessed using the mean and standard deviation of skeletal and/or dental relapse in the anterior or posterior maxilla. It was calculated between the differences of the postoperative final activation of the appliance (mean surgical of expansion changes) and the postoperative final measurement reported (mean stability changes). Results were expressed in millimeters (mm) for width relapse.

### 2.4.2 Analysis of surgical complications

The analysis of surgical complications was assessed as follows: dentoalveolar complications (tooth discoloration, bone resorption, root exposure, loss of attachment and/or gingival recession, tooth mobility), asymmetric expansion and skeletal changes, nasal bleeding, nerve damage, appliance-related complications, other complications (e.g. pain, infections, hematoma, oro-nasal fistula etc).

## 2.5 Risk of Bias in Individual Studies

The assessment of the methodological quality was performed using a scale of risk of bias reported in a previous study by Haas Jr. et al[12] to verify the strength of the scientific evidence in clinical decision-making. The criteria used by these authors

are related to the randomization of the sample, validation of measurements, statistical analysis, the definition of inclusion and exclusion criteria, whether sample loss was reported in the postoperative period, analysis of comparison data between interventions and blinding of the rater were included as criteria.[12]

With respect to the risk of bias for each study analyzed, papers containing all the above-mentioned items were considered low risk, those for which one or two items were missing were deemed medium risk, and studies that did not include three or more items were considered high risk.

Both reviewers independently rated the quality of evidence. Subsequently, both reviewers discussed ratings and justify discrepancies in case they had to reach a final decision.

# 3 Results

## 3.1 Search Strategy

Flow chart of each stage of the systematic review is presented in Figure 1.

### 3.1.1 Main Search

Article's screening from the main search and the grey literature were performed until June 22, 2018. A total of *n*=332 articles were retrieved (PubMed, *n*=148; EMBASE, *n*=55; Cochrane Library, *n*=19; SciELO, *n*=110). Duplicates were removed and 269 articles were analyzed in the selection process.

### 3.1.2 Grey Literature

Grey literature search was made on September 15, 2018. They were found 249 articles from Google Scholar search, in which one article was selected for the eligibility process.[13]

### 3.1.3 Manual Search

Six articles[1,14–18] were included in the final sample of the systematic review.

## 3.2 Study Selection

The 269 articles founded in the main search had the title and abstract consequently read independently by the authors (MEMP and LSM), being 47 articles chosen for full text reading. The correspondent author of Nikolaev et al[19] was contacted for information of the article's abstract in English, since this was available in Russian, receiving a positive feedback of the required information. The concordance rate between authors in the selection of studies for the full text reading was $\kappa$=0.854 (95% confidence interval 0.973-0.735).

## 3.3 Study Eligibility

Forty-seven articles were selected from the Main Search plus the one founded in the Grey Literature[13] search were full-text read by the two blinded authors (MEMP and LSM). The correspondent author from the study Chamberland and Proffit[20] ( Dr. Sylvain Chamberland) was contacted via email for additional

information related to the patient's dental and skeletal data changes and relapse, receiving a positive and ample feedback of the information required.

Therefore, at the end of the eligibility process, 17 studies were included in the systematic review. The reasons for which the other 30 studies were excluded were due the following criteria: Did not evaluate or report any dental and/or skeletal width relapse - 18 studies[19,21–37]. Studies that did not have the minimum follow-up period and/or the minimum sample size on their studies and/or they involved syndromic patients- 5 studies [38–42]. Studies that were not about SARME- 3 studies [43–45]. One study[46] that was not an interventional study-. Two studies that were not original-[47,48](sample was used in previous studies) and one study that did not specify the complications according the type of anchorage device utilized- [49]. The level of inter-rater agreement in the eligibility of the studies was $\kappa$=0,866 (95% confidence interval 0.581-1).

### 3.4 Demographic data extraction

The 23 studies included were divided according to their outcomes in: 11 articles[13,14,16–18,20,50–54] of Relapse/Stability, 8 articles[55–62] of Complications and 4 articles[1,10,15,63] who reported Relapse and Complications.

The studies contemplated in the systematic review were from diverse geographic origins, nevertheless the majority of the studies were produced in Germany[13,58,60,63,], Brazil[18,50,52], U.S.A.[1,51,53] and Turkey.[54,57,61]. The primary studies

were fundamentally retrospective and non-randomized prospective ones, being only 2 articles[10,54] a randomized controlled trial design.

The studies were published in the last 27 years, between 1992-2017. Data extraction revealed 649 patients who underwent SARME procedures for transversal correction of the maxilla. Most of these patients were female, and their mean age ranged from 11 years[55]ne to 59 years[14]. Of the total number of patients, 425 (71.80%) patients were identified with a TB appliance and 183 (28.19%) patients with a BB/HB appliance. In the final subdivision of the articles included, there were founded: 240 (36.97%) patients with TB appliances – 10 (1.54%) with BB appliances (Relapse/Stability), 55 (8.47%) patients with TB appliances – 35 (5.39%) with BB appliances (Stability/Complications) and 171 (26.34%) patients with TB appliances – 138 (21.26%) with BB appliances (Complications). (Table 1)

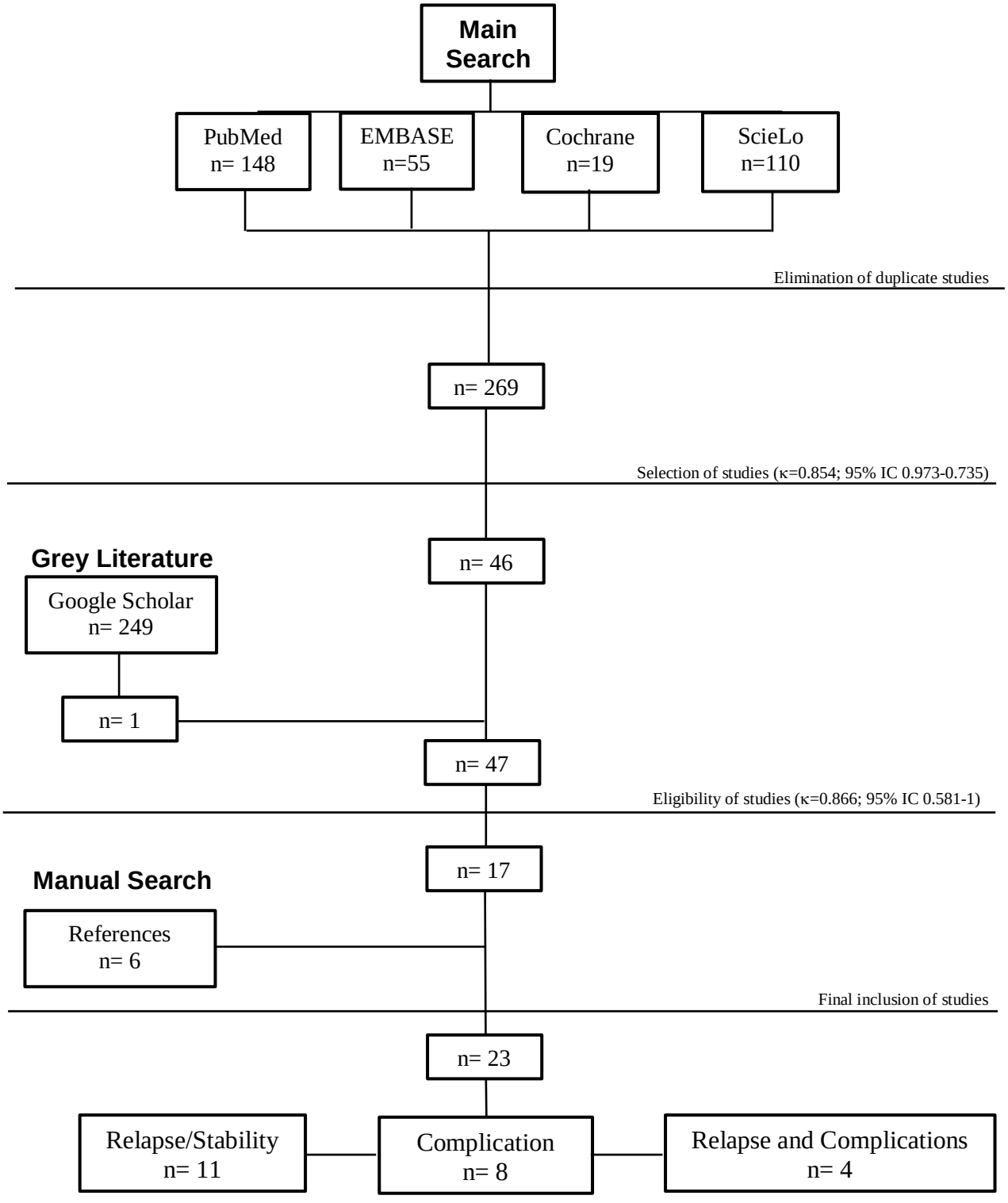



*Figure 1*. Flow chart of the systematic review

***Table 1*. Demographic data for the studies included.**

| Author | Year Published | Type of study | Sample size per type of anchorage | Age, years (Range) | Gender and n | Follow-up Period (months) |
|---|---|---|---|---|---|---|
| **Pogrel M.A et al**[51 A] | 1992 | RCS | TB-h: 12 | 16-32 | F: 8; M :4 | 6-12 |
| **Siqueira D. et a**[50 A] | 2015 | RCS | TB-h: 18 | 23.3(18-35) | F: 12; M: 6 | 6 |
| **De Freitas R.R et al** [52A] | 2008 | PCS | TB-h: 20 | 24.5(20-45) | F: 15; lM:5 | 12 |
| **Gerlach, K.** [63,A] | 2003 | PCS | BB-t: 10 | 25.8(12-37) | F: 9; M:1 | 6 |
| **Northway & Meade**[53,A] | 1997 | PCS | TB-h: 16 | 25.97(17.0-35.3) | F: 10; M: 6 | >12 |
| **Koudstaal M.J et al**[10 A,B] | 2009 | RCT | TB-h: 21<br>BB-t/r: 25 | 25(16-44)<br>33(16-50) | M: 13/ F:8<br>M: 10/ F:15 | 12 |
| **Krey K.F et al**[13 A] | 2008 | PCS | TB-h: 31 | >18 | NS | 3 |
| **Kayalar E. et al**[54 A,B] | 2015 | RCT | TB-h: 10<br>BB-h: 10 | 19.3<br>19.2 | M:6 / F: 4<br>M:3 / F: 7 | 6 |
| **Chamberland & Proffit.**[20 A] | 2011 | PCS | TB-s: 38; 30(at follow-up) | (15-54) | M: 19; F:19 | 15.2 ±5.1 |
| **Bays & Greco**[1 A,B] | 1992 | PCS | TB:19 | 30.2(21.2-39.2) | M: 3; F:17 | 24±15.6 |
| **Strömberg C et al** [14,A] | 1995 | PCS | TB: 20 | 36.3 (18-59) | M: 11; F: 9 | 36(7-96) |
| **Anttila A et al** [15,A] | 2004 | RCS | TB: 15 | 30.6 (16.2-44.2) | M:6; F: 14 | 70.8 (37.2-138) |
| **Hino C et al** [18,A] | 2008 | PCS | TB-h: 19<br>TB-Hs: 19 | 27.5 (18-37)<br>29 (19-39) | NS<br>M: 9/ F: 10 | 4 |
| **Magnusson A et al** [17,A] | 2009 | PCS | TB-h: 31 | 25.9 (15.7-48.9) | M: 17; F: 14 | 76.8±39.6 |
| **Byloff & Mossaz**[16,A] | 2004 | PCS | TB-h: 14 | 27.2 (18.6-41.8) | M: 11; F: 3 | 12 |
| **Laudemann K et al**[60,B] | 2010 | RCT | TB:16<br>BB: 18 | >13/<55 | NS | 20+-1.34 |
| **Dergin G** [61,B] | 2015 | RCS | TB:60 | 17-26 | M: 37; F: 23 | 3 |
| **Verquin M et al** [62,B] | 2017 | RCS | TB: 55 | 13-47(22) | M: 20; F: 35 | 1 |
| **Neyt N. et al** [55,B] | 2002 | RCS | BB: 57 | 18(11-43) | M: 25; F: 32 | 6 |
| **Ramieri G.A et al** [56,B] | 2005 | | BB:29 | 26.4 | M: 8; F:21 | 12 |
| **Günbay T. et al** [57,B] | 2008 | PCS | BB: 10 | 22.3(18-26) | M: 6; F:4 | 2-3 |
| **Landes C.A et al** [64, B] | 2009 | RCS<br>PCS | TB: 26<br>BB: 24 | (13-50) | NS | |
| **Gauthier C. et al** [59,B] | 2011 | PCS | TB: 14 | 23.0 (16.4-39.7) | M: 5; F: 9 | 6 |

RCT: randomized clinical trial; PCS: prospective clinical study; RCS: retrospective clinical study; TB-h: Tooth-Borne Hyrax; BB-t: Bone-Borne TPD (Transpalatal Distractor); BB-t/r: Bone-borne TPD/RPD(Rotterdam Palatal Distractor); BB-h: Hybrid Bone-borne; TB-s: Tooth-Borne Superscrew Super-Spring. TB-Hs: tooth-borne Haas; F: Feminine; M: Masculine; NS: not specified; (A): Stability analysis; (B): Complication analysis. NR: not reported; NI: not informed; NE: not evaluated.

## 3.5 Analysis of Stability

### 3.5.1 Width relapse

In the evaluation of the maxillary width relapse, the studies reported several types of measurements, for which 11 studies,[1,10,14–18,20,51–54,63] used a caliper on dental casts, 1 study[50] employed a dental scanning and a computer software, 1 study[54] used a cone beam computer tomography (CBCT), 1 study[13] used a 3-dimensional reflex microscope on dental casts and 3 studies[20,16,18] used Posterior-anterior (PA) radiographs. A total of 295 patients with TB appliances and 45 patients with BB appliances (52.38% of the overall sample included in the systematic review) were assessed for post-operative stability.

Throughout maxillary distraction, the studies followed a protocol of activation at the time of surgery ranging from no activation[50] to 3 mm[17]. The latency period variated from 1 day[15,17] to 7 days[10,14,20,63]. The activation rates ranged from 0.5mm to 1mm per day and the consolidation period ranged from 2 months[20] to 6 months[15]. The average time needed for expansion during the activation period took between 1.5[51] weeks to 3.5[14] weeks (Table 2).

### 3.5.2 Width expansion and relapse of TB appliances

In patients undergoing SARME procedures with TB appliances, the canine expansion ranged from 3.24± 2.97 mm[17] to 8.20± 3.08mm[13] (dental treatment changes), whereas canine width relapse ranged from -0.20 ± 2.1mm[14] to -2.83 ± 1.9 mm[20] (equivalent to 4.08% - 34.51% respectively of the total dental treatment changes) . The expansion in the premolar region ranged from 5.82 mm[1] to 9.8± 2.7 mm[50], while according to the width relapse in the premolar area, the measurements

ranged from -0.04 ± 0.20mm to -2.02 ± 2.37mm[16] ( 0.48% and a 36.86%[16] of width loss respectively, from the total dental treatment changes). Also it was reported a maximum width gain of 1.1± 2.5mm[10] (equivalent to a width gain of 15.49%[10]).

Measurements for maxillary expansion in the molar region ranged from 5.4 ± 4.55 mm[50] to 9.6 mm[18], whereas for the molar width relapse region, the measurements ranged from -0.02 ±1.1mm[13] to -2.62± 1.8mm[16] (first molar) representing 0.23% to 45% of width relapse and up to -3.64 ± 1.98mm[20] (second molar) representing 49.45% of width relapse from the total dental treatment changes. It was also reported width gains from 0.6%[50] to 6 %[53] at molar region. (Table 3; Graphic 1.A)

The skeletal width's relapse due to TB appliances was reported in 5 studies[10,16,18,20,54]. The expansion measurements at nasal's floor ranged from 1.82 ± 1.61mm[20] to 2.6 ± 1.8mm[10] and in the maxilla level ranged from 1.02 ± 2.1mm[54] to 7.7mm[18]. Nasal's floor relapse ranged from 0.22 ± 1.46mm[20] to -1.4 ± 1.4mm[10] equivalent to 11% - 53.84% respectively of the skeletal treatment changes. The skeletal maxillary level relapse ranged from to -0.24± 2.7mm[16] to 0.1 ± 0.21mm[54] in the posterior maxilla, representing 18.32% of width loss and 9.8% of width gain respectively, of the skeletal treatment changes. (Table3; Graphic 2.A)

### 3.5.3 Width expansion and relapse with BB/HB appliances

Patients undergoing SARME procedures with BB[10,63] appliances had a canine expansion ranged from 6.0 ± 3.4mm[10] to 8.8mm[63] and a canine relapse of -0.15mm[63] to -1.3 ± 3.2mm[10] (1.7% to 21.6% of total treatment changes, respectively). The expansion in the premolar area was of 7.0 ± 3.1mm[10], and the recurrence of -0.1 ±

2.5mm[10] (1.42% of total treatment changes). The expansion in the molar region ranged from 5.3 ± 3.4mm[10] to 8.3mm[63] and the width relapse ranged from -0.35mm[63] to -0.6 ± 1.5mm[10] (4.6% to 11.53% of the skeletal treatment changes). (Graphic 1.B)

The average skeletal expansion due to BB appliances was of 3.1 ± 2.4mm[9] in the maxillary level and 2.4 ± 1.9mm[9] in the nasal floor. The average maxillary level relapse measurement was of -0.5 ± 0.8mm[9] (16% of skeletal treatment changes) and for the nasal floor was -1.0 ± 0.9mm[9] (41.6% of skeletal treatment changes) (Table 3; Graphic 2.B)

Patients having a HB appliances[54] underwent a total expansion at premolar of 4.74 ± 0.79mm[54] and a recurrence of -0.7 ± 0.48mm[54], corresponding to 14.76% of total treatment changes, being the latter statistically significant. For the molar region, the total expansion average was of 6.13 ± 1.62mm[54] and a relapse of 0.11± 1.95mm[54], representing a width gain of 1.79% at this area. The skeletal changes due to HB appliances in the anterior maxilla were of 3.75 ± 1.15mm[54] and in the posterior maxilla of 1.93 ± 2.92mm[54]. The recurrence was of 0.27 ± 0.94mm[54] for the anterior maxilla ( representing a 7.2% width gain of skeletal treatment changes) and of -0.3 ± 1mm[54] for the posterior maxilla ( representing a 15.54% loss of skeletal treatment changes). (Table 3; Graphic 2.B)

***Table 2*. Relapse measurements methods and maxillary expansion protocols of the included studies.**

| Author and year | Type of measurement method | Methodology for width measurement | Maxillary Expansion Protocols | Average time needed for expansion (weeks) |
|---|---|---|---|---|
| **Pogrel M.A et al, 1992**[51] | Caliper on Dental casts | It was measured on molar region with a caliper. | ETOS: 1mm. AR: twice daily, until desired expansion achieved. | 1.5-3.5 |
| **Siqueira D. et al 2015** | Dental cast scanning (D-250, 3Shape) | Dental casts were scanned with a 3D scanner (D-250, 3Shape, Copenhagen, Denmark). Linear measurements were taken by means of Geomagic Studio 5™ (Research Triangle Park, USA) | ETOS: No activation.. LP:3 days. Twice daily activations until desired correction, no OC. CP: 3 months. | NS |
| **Freitas R.R et al 2008** | Starret digital millimetric caliper model 727 | The measurements were made in millimeters, with a Starret digital millimetric caliper model 727 | ETOS: NS. 2.0mm(10 activations) at TOS. LP: 2 days 4 daily (0.4mm morning-0.4mm afternoon) activations(0.8mm) until planned expansion. CP: 6 months. | 2 |
| **Gerlach, K.et al, 2003** | Plaster casts and caliper | Dental casts for width measurements of ICD, ADA and PDA. | ETOS: NS. LP: 7days. AR: 0.4mm/day with two screw turns per day. CP: 3 months. Distraction until cross-bite completely corrected | 3 |
| **Northway & Meade. 1997** | Dial caliper with dental casts | Transverse width of canines' cusp tips or most labial surface and the mesiolingual cusp tips and buccal groove of first molars | NS | NS |
| **Koudstaal M.J et al 2009** | Dental casts, Plane radiographs and dicom-data program Easy-ViewWeb (2005, PhilipsMedical systems, Best, Netherlands). | Measurements of dental casts with an electronic digital caliper (kraftixx®, art. 0906-90) with an accuracy of 0.02mm. Landmarks: cusp of canine, tip of buccal cusp of premolar and tip of disto-buccal | ETOS: NS. LP: 1week. AR: 1mm/day, until desired expansion was obtained. CP: 3months. | NS |

**Table *2*. (*Continued*)**

| | | | | |
|---|---|---|---|---|
| | | cusp of first molar to measure arc width. Skeletal widening was measured with PA cephalograms. | | |
| **Krey K.F et al 2008** | 3-dimensional reflex microscope on dental casts | Casts measured with a reflex microscope. The x-, y- and z-coordinates are monitored continuously by linear encoders and can be stored on command in the computer (C3D software, Reflex Measurement Ltd., London, UK) | ETOS: eight quarters: 1.92mm. AR: 2 daily activations,0.48mm daily.. LP: NS. CP: 3 months. | NS |
| **Kayalar E. et al 2015** | CBCT | On scanned CBCT images, measurements were made at the width between the buccal cusp tips of the first premolars and first molars. Scanora 3D; Soredex, Tuusulu, Finland). Subsequent scans were taken with a voxel size of 0.25 mm, at 12.5 mA, with a field of view (FOV) of 14.5 cm, and following a low-dose protocol with 90 kVp instead of the standard CT setting of 120 kVp. Measurements were made using Mimics 16.0 (Materialise, Belgium) | ETOS: 1mm. AR: 2 turns per day, 0.25mm per turn. LP: NS. CP: 6months. | 2 |
| **Chamberland & Proffit. 2011** | Dental casts and plane posteroanterior radiographs, measurement of dental casts with a digital caliper | Inter-canine width was measured in the cusp tip, Inter-premolar width was measured in the mesial fossa, inter-molar was measured in the central fossa | ETOS: NS. LP: 7 days. 0.25, twice daily. CP: 2months. | 2-3 |
| **Bays & Greco, 1992** | Caliper on dental casts | From occlusal pit to occlusal pit in posterior teeth and for the canine, the height of contour of the most distobuccal surface. | ETOS: 1.5-2.0mm. LP: 5 days. AR: Quarter turns per day until desired expansion is achieved. CP: NS. No OC needed. | NS |
| **Strömberg C et al ,1995** | Caliper on dental casts | Shortest distance at the gingival margin between the first upper molars and between the canines. | ETOS: NS. LP: 7days. AR: 0.25mm per day until desired expansion. | 3.5 |
| **Anttila A et al, 2004** | Digital sliding caliper | Measurements from dental canine cusps, palatal premolar cusps and the mesiopalatal cusps of the molars | LP: 1 day. ETOS: 3-6 turns until minor diastema between central incisors. AR: 0.5mm/day(two turns daily). CP: 6 months. | 3(2-7) |

**Table *2*. (*Continued*)**

| | | | | |
|---|---|---|---|---|
| **Magnusson A et al, 2009** | Dental models | Direct measurements were made with a digital caliper (model Mitutoyo 500-171, Kanawaga, Japan) to he nearest 0.01mm. Two Reference points were taken at the cusp tips of the canines and the most prominent cervical point of the palatal ridge, and on the first molars, it was measured between the mesiobuccal cusp tips and between the most cervical point of the palatal fissure | ETOS: 3mm(12 turns). LP: one day. AR: one turn twice a day, 0.5mm/day. An overexpansion of half a cusp width bilaterally was achieved. | NS |
| **Byloff & Mossaz, 2004** | Models, occlusal radiographs, PA radiographs, | Using a dial caliper, measuring to 1/1000mm, it was measured the distances between canine cusp tips, the premolars and molars (occlusal crown center) on dental casts. On PA radiographs, a midline reference point was determined on the line connecting each orbit at the intersection between the greater wing of sphenoid and the inner cortex of the orbit at the landmark described as latero-orbitale. From the midline, two perpendicular lines were drawn 5 mm above the inserted pin and were measured to monitor skeletal expansion. | ETOS: four quarter turns (1mm). LP: 3 days. AR: one quarter turn per day until necessary amount of expansion. | 3-5 |
| **Hino C et al, 2008** | Dental casts and PA x-rays. | On PA radiographs and plaster orthodontic models, linear measurements were obtained with a digital caliper (Mitutoyo) of 0.01mm precision. | ETOS: 1.6mm. LP: 4 days. AR: 2 quarter turns per day. (twice a day), corresponding 0.4mm of daily expansion, until necessary expansion, but it was over-expanded 2mm at molar region. RP: 4 months. | NS |

ETOS: Expansion at Time of surgery; LP: Latency period; AR: Activation rate; OC: Over-correction; RP/CP: Consolidation period; BB: Bone- Borne; TB: Tooth-Borne; TPD: Transpalatal Distractor; ICD: inter-canine dental width; ADA: anterior dental width; PDA: posterior dental width; NS: not specified; PA: Posterior-anterior; CBCT: cone beam computer tomography. FOV: Field of view.

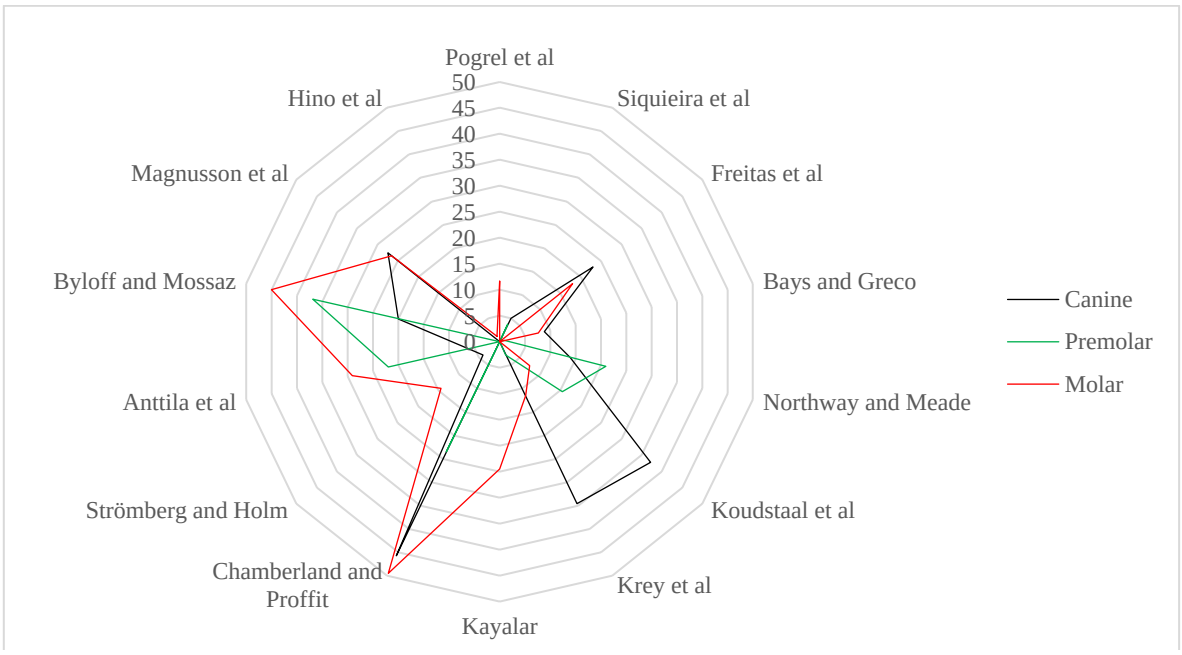
***Table 3.*** **Analysis of width stability/relapse as the outcome of the included articles.**

| Author and year | Type of anchorage and *n* | Method of analysis | Dental width relapse (mm), SD, (%) from TxC | | | Skeletal width relapse(mm), SD, (%) from TxC | | Dental treatment changes (mm), SD | | | Skeletal treatment changes(mm),SD | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Canine | Premolar | Molar | Nasal floor | Maxilla level | Canine | Premolar | Molar | Nasal floor | Maxilla level |
| **Pogrel M.A et al, 1992**[51] | TB-h: 12 | Dental casts and caliper. | NE | NE | -0.88 ± 0.48 (11.73%) | NE | NE | NE | NE | 7.50 | NE | NE |
| **Siqueira D. et al, 2015**[50] | TB-h: 18 | Dental cast scanning (D-250, 3Shape) | -0.29 ± 0.16 [5%][a] | -0.35 ± 0.28 [3.7%][a] (1st premolar)<br>-0.04± 3.12 (0.5%)* (2nd premolar) | 0.06 ± 0.45 (0.6%)[a] (1st molar)<br>-0.03± 4.62 (0.55%) (2nd molar) | NE | NE | 5.87± 2.40 | 9.8± 2.7 (1st premolar)<br>9.49± 3.14 (2nd premolar) | 9.26±4.19 (1st molar)<br>5.4± 4.55 (2nd molar) | NE | NE |
| **Freitas R.R et al, 2008**[52] | TB-h: 20 | Starret digital millimetric caliper model 727 | -1.69± 0.31 [23%][b] | NE | -1.48± 0.2 (18%)[b] | NE | NE | 7.22± 3.0 | NE | 8.06±3.06 | NE | NE |
| **Gerlach and Zahl, 2003**[63] | BB-t: 10 | Plaster casts and caliper | -0.15 (1.7%)[a] | NE | -0.35 (4.6%)[a] | NE | NE | 8.8 | NE | 8.3 | NE | NE |
| **Northway and Meade, 1997**[53] | TB-h: 16 | Dial caliper with dental casts | -0.47± 0.6 [14%][b] | NE | 0.14± 1.1 [6%][b] | NE | NE | 3.45±2.1 | NE | 5.5±2.9 | NE | NS |
| **Koudstaal M.J et al, 2009**[10] | TB-h: 21<br>BB-t/r: 25 | Dental casts, Plane radiographs | TB: -2.2 ± 3.8* (37.2%)[b]<br>BB: -1.3 ± 3.2* [21.6][b] | TB: 1.1 ± 2.5 [15.49%][b]<br>BB: -0.1 ± 2.5* [1.42%][b] | TB: -0.5 ± 1.8 [7.35%][b]<br>BB:-0,6 ± 1.5 [11.53%][b] | TB: -1.4±1.4* (53,84%)<br>BB: -1.0±0.9* (41,6%) | TB: -0.4±1.3 (12.90%)<br>BB: -0.5± 0.8* (16%) | TB: 5.9± 3.6*<br>BB: 6.0± 3.4* | TB: 7.1± 3.5*<br>BB: 7.0± 3.1* | TB: 6.8± 2.9*<br>BB: 5.3± 3.4* | TB: 2.6±1.8*<br>BB: 2.4± 1.9* | TB: 3.1±2.0*<br>BB: 3.1±2.4* |
| **Krey K.F et al, 2008**[13] | TB-h: 31 | 3-dimensional reflex microscope on dental casts | -2.83* [34.51%][c]* | -0,04± 0.20* [0,48%] (1st premolar)<br>-0.23± 0.07* [2.8%] (2nd premolar) | -0,02± 0.19* [0,23%] (1st molar)<br>-0.68± 0.05* [11.5%] (2nd molar) | NE | NE | 8.20± 3.08* | 8.22± 2.77* (1st premolar)<br>8.20± 4.22* (2 premolar) | 8.37± 3.49* (1st molar)<br>5.87± 5.07* (2nd molar) | NE | NE |

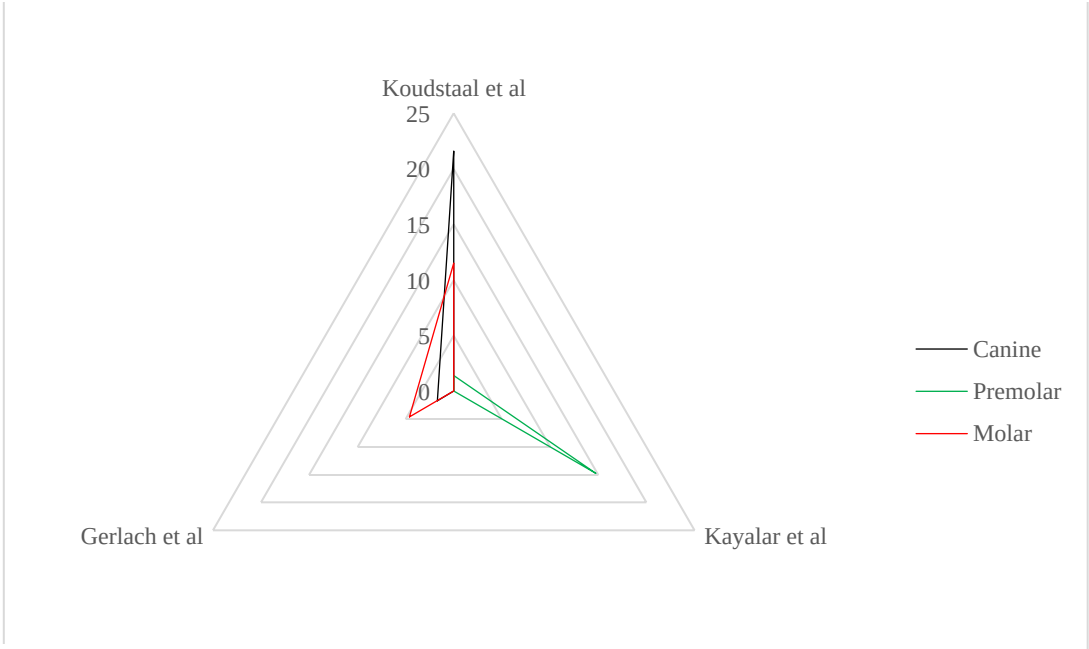
***Table 3*. Continued**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kayalar E. et al, 2015**[54] | TB-h: 10<br><br>HB-h: 10 | CBCT | NE | TB: 0.16 ±1.33 [2.6%][c] (1st premolar)<br><br>HB: -0.7 ± 0.48* [14.76%][c] (1st premolar) | TB: -0.32 ±1.31 [24.49%][c] (1st molar)<br><br>HB: 0.11 ± 1.95 [1.79%][c] (1st molar) | NE | TB: AM -0,25± 1.9 (5.45%) PM 0.1±0.21 (9.80%)<br><br>HB: AM 0.27±0.94 (7.2%) PM -0.3±1 (15.54%) | NE | TB: 6.13±1.47* (1st premolar)<br><br>HB: 4.74± 0.79 (1st premolar) | TB: 7.12± 1.75* (1st molar)<br><br>HB: 6.13± 1.62 (1st molar) | NE | TB: AM 4.58± 1.8* PM 1.02±2.1<br><br>HB: AM 3.75±1.15* PM 1.93±2.92 |
| **Chamberland and Proffit, 2011**[20] | TB-s: 30 | Dental casts and plane radiographs | -2.60 ± 1.9[b]* [45.7%] | -1.787 ±2.239[b] [23.47%] (1st premolar)<br><br>-1.65±2.4[b] [21.04%] (2nd premolar) | -1.832 ±1.834[b]* [24.11%] (1st molar)<br><br>-3.64±1.98[b]* [49.45%] (2nd molar) | 0.223±1.462[&] (11.1%) | -0.035±1.556[&] (1%) | 5.69±2.03*[&] | 7.61± 1.86* (1st premolar)<br><br>7.86± 1.86* (2nd premolar) | 7.60±1.57* (1st molar)<br><br>7.36± 1.85* (2ns molar) | 1.82± 1.61*[&] | 3.58±1.63 *[&] |
| **Bays and Greco, 1992**[1] | TB: 19 | Dental casts | -0.39±0.79[b] [8.8%] | 0.064 ±1.0 [1%] [b] | -0.45± 0.69[b] [7.7%] | NE | NE | 4.89 | 5.82 | 6.23 | NE | NE |
| **Strömberg and Holm, 1995**[14] | TB: 20 | Dental casts | -0.2± 2.1[b] [4.08%] | NS | -1.2± 1.3[b] [14.45%] | NE | NE | 5.0± 2.2 | NE | 8.3± 2.6 | NE | NE |
| **Anttila A et al, 2004**[15] | TB: 15 | Dental casts | 0.5 [6%] | -0.7 [12%] (1st premolar)<br><br>-1.5 [22%] (2nd premolar) | -1.3* [21%] (1st molar)<br><br>-1.4* [29%] (2nd molar) | NE | NE | NI | NI | NI | NE | NE |
| **Byloff and Mossaz, 2004**[16] | TB-h:14 | Dental casts and PA radiographs | -0.94±2.3[b] [20%] | -2.02 ± 2.37[b] [36.86%] (1st premolar)<br><br>-1.38± 2.7[b] [20.14%] (2nd premolar) | -2.62± 1.8[b] [45.01%] (1st molar)<br><br>-1.48± 0.98[b] [36.81%] (2nd molar) | NE | -0.24± 2.7 (18.32%) | 5.19± 2.28 | 8.08± 1.78 (1st premolar)<br><br>8,26± 2.48 (2nd premolar) | 8.73± 2.49 (1st molar)<br><br>5.48± 2.53 (2nd molar) | NE | 1.31± 3.03 |
| **Magnusson A et al, 2009**[17] | TB-h: 31 | Dental casts | -0.89± 2.95 [27.46%] | NE | -1.54± 3.63 [26.55%] | NE | NE | 3.24± 2.97* | NE | 5.80± 3.73* | NE | NE |
| **Hino C et al, 2008**[18] | TB-h: 19<br>TB-Hs: 19 | Dental casts and PA x-rays. | NE | NE | TB-h: -0.1* [1.12%]<br><br>TB-Hs: 0.0 [0%] | NE | TB-h: -1.4 (18.18%)<br><br>TB-Hs: -0.80 (10.38%) | NE | NE | TB-h: 8.9<br><br>TB-Hs: 9.6 | NE | TB-h: 7.70<br><br>TB-Hs: 7.7 |

[a] 6-month follow-up; [b]≥12-month follow-up; [c]6<x≥3month follow-up. Negative Values: Loss of width; Positive Values: Gain of width; CBCT: Cone Beam Computed Tomography; PA x ray: posterior-anterior radiograph; NS: Not specified (*): Statistically significant; TB-h: Tooth-Borne Hyrax; TB-Hs: tooth-borne Haas; BB-t: Bone-Borne TPD (Transpalatal Distractor); BB-t/r: Bone-borne TPD/RPD(Rotterdam Palatal Distractor); BB-h: Hybrid Bone-borne ; TxC: treatment changes. AM: anterior maxilla; PM: posterior maxilla. PA: Posterior-anterior. (&): data consulted to the author. NE: not evaluated; NI: not informed

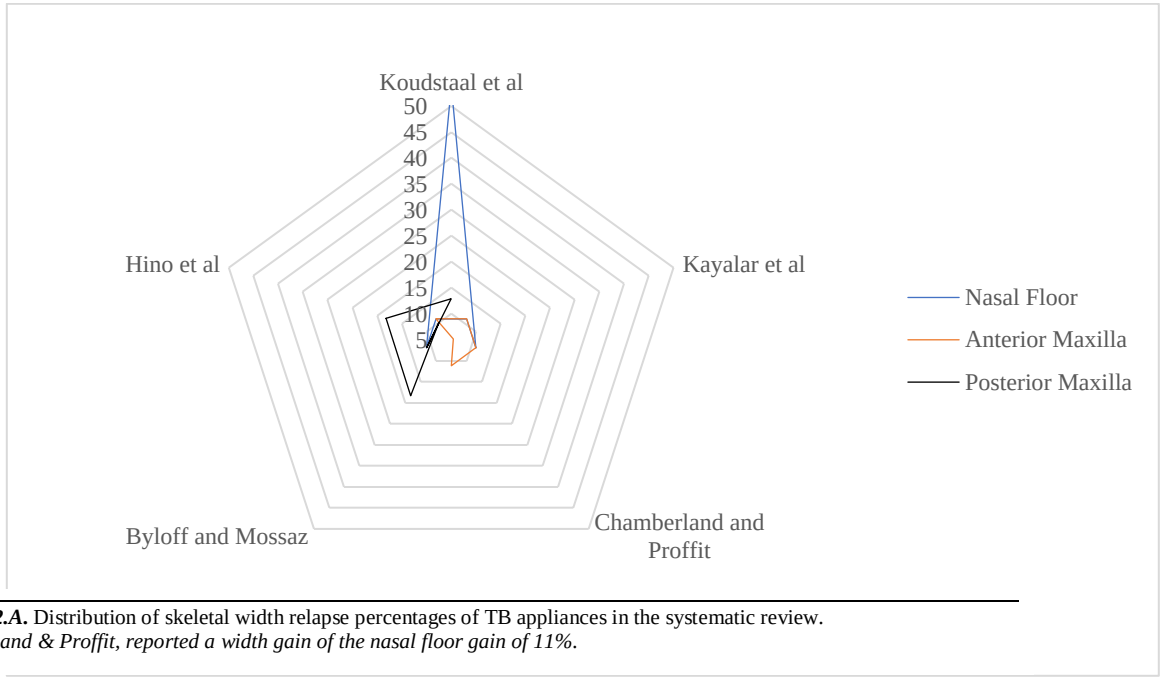



***Graphic 1.*** **A.** Distribution of dental width relapse percentages of TB appliances in the systematic review.
*Siqueira et al. reported a molar width gain of 1% (not represented graphically)*
*Northway & Meade reported a molar width gain of 6% (not represented graphically)*
*Kayalar et al reported a premolar gain of 2.6% (not represented graphically)*

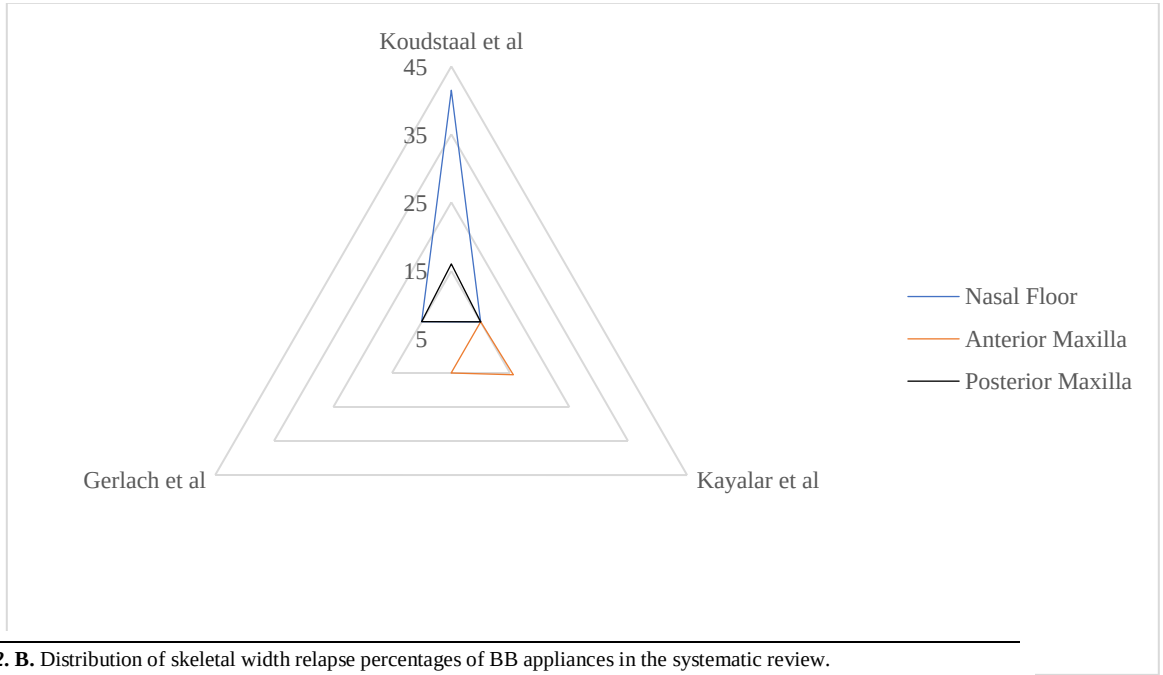



***Graphic 1.*** **B.** Distribution of dental width relapse percentages of BB appliances in the systematic review.
*Kayalar et al. reported a molar gain of width of 1.79% (not represented graphically)*

Graphic 1. Distribution of dental width relapse of TB and BB appliances




***Graphic 2.A.*** Distribution of skeletal width relapse percentages of TB appliances in the systematic review.
*Chamberland & Proffit, reported a width gain of the nasal floor gain of 11%.*




***Graphic 2*. B.** Distribution of skeletal width relapse percentages of BB appliances in the systematic review.
*Kayalar et al compared a TB vs HB device.*

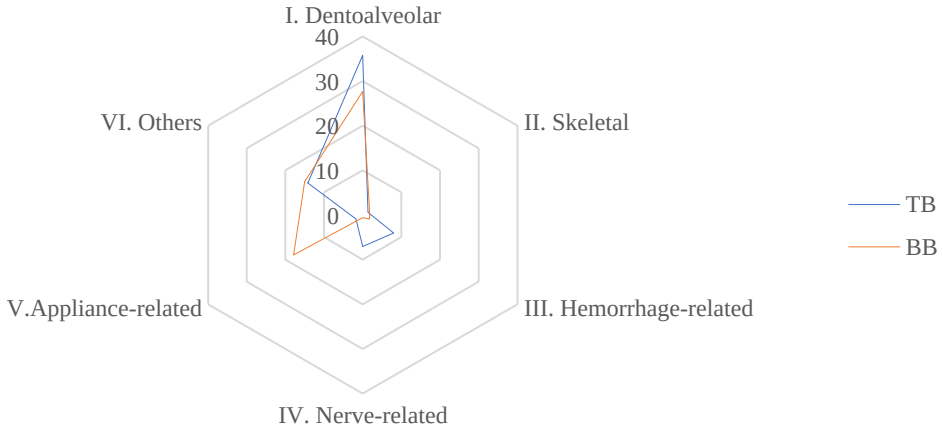
Graphic 2. Distribution of skeletal width relapse of TB and BB appliances

### 3.6 Analysis of TB/BB Surgical Complications

Twelve studies[1,10,15,55,57–63] were assessed as outcomes of SARME/SARPE procedures who reported TB and/or BB appliances, comprehending 399 patients (61.4% of the total systematic review sample), distributed in 226 patients with TB appliances (56,6%) and 173 patients with BB appliances (43.3). (Table 4).

Of the total studies who reported complications, 155 patients had TB appliances (68.58%) and 111 patients had BB appliances (64.16%). For better understanding and association, complications were categorized as follows: I. Dentoalveolar, II. Skeletal, III. Hemorrhage related, IV. Nerve related V. Appliance-related VI. Others. (Table 4)

Overall ( studies who evaluated TB and BB complications) , the most prevalent were: 1. bone resorption; accounting 41 cases from 3 studies[15,58,59] with TB appliances (18.14% of the total TB complications) and 2. appliance related complications, accounting 31 cases from three studies[55–57] with BB appliances (17.91% of the total BB complications). (Graphic 3).




**Graphic 3.** Prevalence of complications of TB and BB appliances in the systematic review.

Nevertheless, two complications were the most commonly reported: 1. appliance related complications (4 cases (1.76%) in two studies[15,62] with TB appliances and 31 cases (17.91%) in three studies[55–57] with BB appliances) and 2. Nasal bleeding complications: 18 cases (7.96% of the total TB complications) in three studies[1,61,62] with TB appliances and in 3 cases (1.73% of the total BB complications) in two studies[55,57] with BB appliances. The least common complication reported was tinnitus in one study.[61](Figure 2).

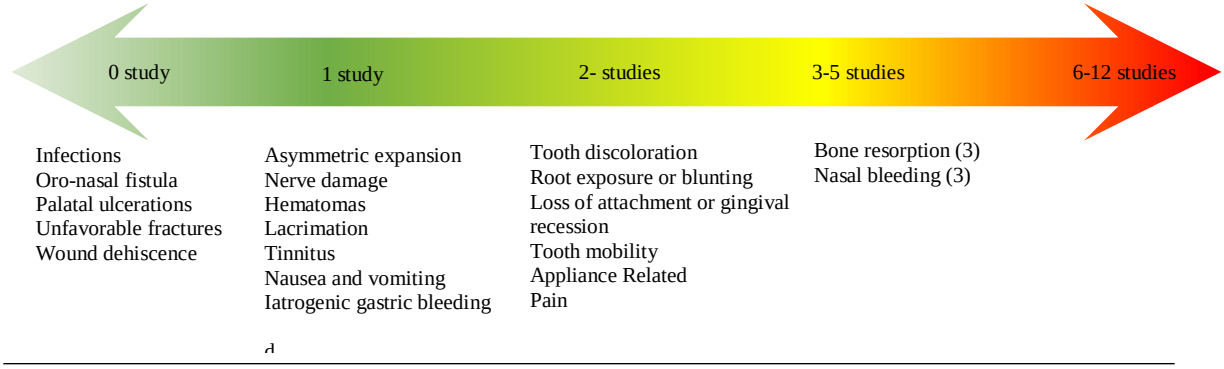



***Figure 2.*** **(A)** Complications most often reported in TB appliances: Number of the studies out of the 12 included that reported complications of TB and BB devices in this systematic review.

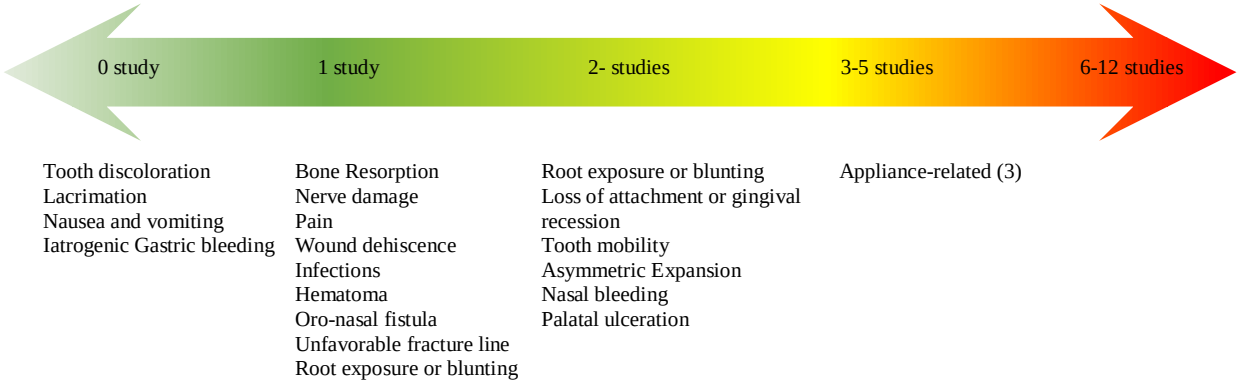



***Figure 2.*** **(B)** Complications most often reported in BB appliances: Number of the studies out of the 12 included that reported complications of TB and BB devices in this systematic review.

Regarding BB appliances, no cases of tooth discoloration nor lacrimation were reported. For TB appliances, no cases of infections nor oro-nasal fistulas were reported. (Table 4).

Gauthier et al.[59] reported the highest rate of patients with complications, being 31 events out of the 14 patients analyzed with TB appliances, resulting in an average of 2.2 complications per patient. Koudstaal et al.[10], reported the lowest prevalence of patients with complications, resulting in 1 complication in 21 patients (4.76%) for TB appliances and 2 complications for 25 patients (8%) for BB appliances (Table 4).

### 3.7 Assessment of methodological quality

Risk of bias was considered high in 19 articles[1,13–18,20,50–53,55–57,59,61–63], medium in 3 studies[10,58,60], in which the criteria for quality assessment not founded in these articles are related to sample randomization, comparison between treatments and blind assessment, and as a low risk of bias in one study[54]. (Table 5)

***Table 4*. Type of anchorage and complication data for the studies included.**

| Author and year | Type of anchorage and *n* | I | | | | | II | III | IV | V | VI | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tooth Discoloration /Absence of thermal sensitivity | Bone Resorption | Root Exposure or root blunting | Loss of Attachment /> probing/ gingival recession | Tooth Mobility | Asymmetric Expansion | Nasal Bleeding | Nerve Damage | Appliance related | Pain | Infections | Hematoma | Oro-nasal fistula | Lacrimation | Other | Total |
| **Gerlach K et al 2003** | BB: 10 | | | 1 | | | | | | | | | | 1 | | | 2 |
| **Koudstaal M.J et al, 2009** | TB:21 | 1 | | | | | | | | | | | | | | | 1 |
| | BB: 25 | | | | | | 2 | | | | | | | | | | 2 |
| **Kayalar et al, 2016** | TB:<br>BB: | | | | | | | | | | | | | | | | |
| **Bays & Greco, 1992** | TB: 19 | | | | | | | 1 | | | | | | | | | 1 |
| **Anttila et al, 2004** | TB: 15 | | 1 | 1 | | | | | | 1 | | | | | | 1(palatal irritation) | 4 |
| **Laudemann et al, 2010** | TB: 16 | | | | 16 | | | | | | | | | | | | 16 |
| | BB: 18 | | | | 18 [a] | | | | | | | | | | | | 18 |
| **Dergin et al, 2015** | TB: 60 | | | | | | | 12 | | | 15 | | | | 5 | 1 (Tinnitus) | 33 |
| **Verquin et al, 2017** | TB: 55 | 1 | | 2 | | 2 | 3 | 5 | 16 | 3 | 4 | | 2 | | | 1 (Iatrogenic gastric bleeding) 4 (Nausea and vomiting) | 43 |
| **Neyt et al 2002** | BB: 57 | | | | | | | 1 | 1 | 19 | | 2 | 3 | | | 3 (Palatal ulceration) | 29 |
| **Ramiere et al, 2005[c]** | BB: 29 | | | | 1 | 2 | | | | 10 | | | | | | 9 (palatal ulceration) 4(unfavor-able fracture line | 26 |
| **Günbay et al, 2008** | BB: 10 | | | | | 2 | 1 | 2 | | 2 | 3 | | | | | 1 (Wound dehiscence) | 11 |
| **Landes et al, 2009** | TB: 26 | | 26[b] | | | | | | | | | | | | | | 26 |
| | BB: 24 | | 24 | | | | | | | | | | | | | | 24 |
| **Gauthier et al, 2011** | TB: 14 | | 14 | | 11 | 6 | | | | | | | | | | | 31 |
| ***N* patients with complications as outcomes of the systematic review** | TB: 226 | 2 (0.88%) | 41 (18.14%) | 3 (1.32%) | 27 (11.94%) | 8 (3.5%) | 3 (1.32%) | 18 (7.96%) | 16(7.07%) | 4 (1.76%) | 19 (8.04%) | 0 | 2 (0.88) | 0 | 5 (2.21%) | 7 (3.09%) | 155 (68.58%) |
| | BB: 173 | 0 | 24 (13.87%) | 1(0.57%) | 19 (10.9%) | 4 (2.31%) | 3 (1.73%) | 3 (1.73%) | 1 (0.57%) | 31 (17.91%) | 3 (1.73%) | 2 (1.15%) | 3 (1.73%) | 1 (0.57%) | 0 | 17 (9.82%) | 112 (64.73%) |

**The classification of complications is organized by: I. Dentoalveolar, II. Skeletal, III. Hemorrhage related, IV. Nerve related V. Appliance-related VI. Other.**

[a]: Greater overall attachment loss was observed in BB devices.

[b]: Greater vestibular resorption occurred in the 1st and 2nd premolars in TB appliances.

***Table 5.*** **Quality assessment of included studies**

| QUALITY CRITERIA FOR RELAPSE STUDIES | POGREL MA ET AL, 1992[51] | SIQUEIRA D. ET AL 2015[50] | FREITAS R.R ET AL 2008[52] | GERLACH, K. 2003[63] | NORTHWAY & MEADE 1997[53] | KOUDSTAAL M.J ET AL 2009[10] | KREY K.F ET AL 2008[13] | KAYALAR E. ET AL 2015[54] | CHAMBERLAND & PROFFIT 2011[20] | BAYS & GRECO 1992[1] | STRÖMBERG C ET AL 1995[14] | ANTILLA A ET AL, 2004[15] | HINO C ET AL, 2008[18] | MAGNUSSON A ET AL, 2009[17] | BYLOFF &MOSSAZ, 2004[16] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE RANDOMIZATION | No | No | No | No | No | Yes | No | Yes | No | No | No | No | No | No | No |
| COMPARISON BETWEEN TREATMENTS[+] | No | No | No | No | No | Yes | No | Yes | No | No | No | No | No | No | No |
| BLIND ASSESSMENT | No | No | No | No | No | No | No | Yes | No | No | No | No | No | No | No |
| VALIDATION OF MEASUREMENTS | No | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes |
| STATISTICAL ANALYSIS | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| DEFINED INCLUSION AND EXCLUSION CRITERIA | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| REPORT OF FOLLOW-UP | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | | | | | | | | | | | | | | | |
| RISK OF BIAS ASSESSMENT | High | High | High | High | High | Medium | High | Low | High | High | High | High | High | High | High |

***Table 5.*** **Continued.**

| QUALITY CRITERIA FOR COMPLICATIONS STUDIES | LAUDEMANN ET AL, 2010[65] | DERGIN ET AL 2015[60] | VERQUIN ET AL, 2017[61] | NEYT ET A, 2002[62] | RAMIERE ET AL, 2005[55] | GÜNBAY ET AL, 2008[56] | LANDES ET AL, 2009[57] | GAUTHIER ET AL, 2011[58] |
|---|---|---|---|---|---|---|---|---|
| SAMPLE RANDOMIZATION | No | No | No | No | No | No | No | No |
| COMPARISON BETWEEN TREATMENTS[+] | Yes | No | No | No | No | No | Yes | No |
| BLIND ASSESSMENT | Yes | No | No | No | No | No | Yes | No |
| VALIDATION OF MEASUREMENTS | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes |
| STATISTICAL ANALYSIS | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| DEFINED INCLUSION AND EXCLUSION CRITERIA | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| REPORT OF FOLLOW-UP | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | | | | | | | | |
| RISK OF BIAS ASSESSMENT | Medium | High | High | High | High | High | Medium | High |

[+]Comparison between the TB and BB or HB appliances in SARME Bias risk potential estimation: High: 0 to 4 yes – Medium: 5 to 6 yes – Low: 7 yes.

# 4. Discussion

It is well known that transverse skeletal expansion in patients with maxillary atresia is considered the least stable and predictable[66]. Segmental maxillary and conventional LeFort I osteotomies are employed to correct transversal deformities in the mature patients, being the SARME one of the most stable and common procedures[3].

Tooth-borne and bone-borne appliances in SARME procedures have been introduced for achieving maxillary expansion.[67,68] The stability, technique, expansion protocols and complications of the appliances have been reported by several studies[1,10,37,51,53,56,62,63], as well as which appliance provides more skeletal and dental expansion through a systematic review and meta-analyses recently published[69]. However, there is still no consensus whether which appliance has the best outcomes in terms of less dental and skeletal width relapse and the fewest complications during the post-operative period.

Therefore, the main purpose of this study was to answer two main queries through a systematic review: (1) Which type of distraction device provides the best stability in the post-operative period? And (2) What are the main complications of the distraction appliances in SARME procedures?

For this systematic review, a similar and abroad strategy search was used as described in another study[70], prioritizing sensitivity over specificity using the highest level of evidence available. Since there is no "SARME stability", "tooth-borne stability" nor "bone-borne stability" as the MeSH or Emtree terms, a combination of "palatal expansion technique", "recurrence", "complication, postoperative" and its proper entry terms derived, were combined with "tooth-borne", "bone-borne" and "hybrid appliance" in order to mitigate the effects of specificity and try to encompass the greatest amount of articles of

the four databases of the main search. The same strategy was used for grey literature search in order to be more sensitive for the primary outcomes. During the eligibility process, blinding of articles (regarding title, abstract, authorship and any other contact information detailed in the article) is very important to avoid any selection bias. The kappa inter-rater coefficient was considered to have an excellent level of agreement between the authors MEMP and LSM (according to Landi and Koch classification[71]) in the processes of selection of the studies and the eligibility of the studies, being of $\kappa$= 0.854 (95% confidence interval 0.973-0.735) and $\kappa$=0,866 (95% confidence interval 0.581-1) respectively. This made the study suitable for reproducibility.

Following a pertinent and copious analysis in the eligibility process, 23 studies[1,10,13–18,20,50–63] were selected in the final sample (including 6 studies[1,14–18] of the manual search) in the present systematic revision, for which the best methodological studies are advocated to Kayalar et al. 2016[54] (low risk of bias) and Koudstaal et al 2009[10] (medium risk of bias) for stability analysis of TB vs BB/HB appliances, since they were randomized control trials. Other two studies[58,60] also had a medium risk of bias, with no sample randomization.

Two studies were discarded of the eligibility process for not being original. It is worth mentioned, however, that both studies met the methodological design criteria for this systematic review. The study by De Gijt et al. 2017[48] evaluated seventeen of the 42 patients from the original study by Koudstaal et al. 2009[10], being the purpose of the former to evaluate the long-term dental and skeletal effects of TB and BB appliances with the sample from the original study. Thus, the study of De Gijt et al. 2017[48] was excluded of the present study because as the proper article discusses: “the number (of patients) who

responded was too small to compare the two types of distractor (TB vs BB)", and besides, the original study presented more completed data. The second study excluded was Chamberland and Proffit, 2008[47], because despite the fact that it was published as the first original study, the most recent one published by the authors (Chamberland and Proffit, 2011[20]) has a further longitudinal data for short-term and long-term stability, with more sample included as well.

After data extraction and analysis, the included studies that were of relapse as an outcome were organized by dividing them in two postoperative main groups for each tooth-borne and/or bone-borne appliances when data was available: 1. Dental and skeletal width relapse and 2. Dental and skeletal width expansion (treatment changes). The analysis of these outcomes served to establish the width stability in maxillary expansion for each distraction appliance.

Regarding TB appliances, generally the greatest relapse occurred in the molar region[1,14–17,20] (either 1st or 2nd molars) compared to the canines, with relapse percentages reaching up to 35% in the canines and to 45% in the molars. However, in various studies[10,13,50,52] when canine relapses were greater than in the molar region, one plausible explanation resides in the fact that dental width treatment changes were proportionally greater as well, therefore implying that the greater the expansion achieved, the greater the degree of recurrence observed, even though some authors reported no association between the expansion degree and the relapse rate[20,52]. It is also pertinent to associate greater canine relapses in TB appliances to the surgical technique applied[13,52]. When the PMD is not performed, the associated forces exerted in the palatal mucoperiosteum and surrounding bucco-oral muscles could increase the resistance in

the posterior regions, leading to less width molar expansion and consequently less molar width relapses in the consolidation periods[17], however some authors demonstrated that PMD is not necessary to achieve expansion of the maxilla.[51,53] Overall, the skeletal changes seem to be a determinant factor when considering maxillary width relapse in studies analyzing TB appliances, since dental relapses are associated to dental tipping and lateral rotations of the maxillary halves[10,16]. The expansion of the maxillary halves appeared to increase as the retention period increases as well, as shown in several studies[16,20]. The maxillary skeletal width relapses were up to 18%[16] in the maxilla and of 53%[10] in the nasal floor (when reported), showing that one possible factor of maxillary relapse lies on the TB appliances not having the rigidity needed to withstand the exerted forces that are delivered, thus causing tipping.

The relapse of BB appliances was only analyzed in two articles included in this systematic review, being one a RCT[10] and the other a PCS.[63] For HB appliances, just one study[54] compared TB with HB appliances. The dental relapse in the BB groups founded width relapse percentages that ranged from 1.7-21.6% for the canine region to 4.6-11.5% for the molar regions, being lower than the ranges reported for TB appliances. Lower relapse percentages may be explained due to a more parallel distribution of forces exerted by the distractor to the maxillary halves, reducing segmental and tooth tipping. The difference regarding the relapse of width of BB appliances between the studies could be related to the type of surgical technique employed, the location/direction of the expander screw[54] and the patients' age. HB appliances presented less dental expansion in the anterior region, although they presented less dental tipping and more relapse percentages in the molar region when compared to the TB group[54]. This could be

explained because of the tipping patterns that occurred in the dentoalveolar complex as they changed in an outward manner in the TB appliances during the consolidation period and therefore, not showing a true skeletal width relapse. On the contrary, bone-anchored appliances provoked an inward dental rotation, associated in part to the type of anchorage, mechanism of expansion and the forces provided by the palatal mucoperiosteum resistance and surrounding muscles[54,63].

The rationale to explain why the canine region has greater relapses than the posterior region in BB appliances resides is the fact that are localized more posteriorly in the palatal vault, thus creating a major resistance to recurrence of the maxillary halves. Another plausible explanation is the alignment of the maxillary dental arc in the consolidation period, since as seen in several studies[54,63] of TB and BB groups. During the consolidation periods the relapse varies independently of the type of appliance, thus the stability in SARME procedures must be seen after the proper arc form coordination and/or when the final anterior-posterior and vertical relationships have been achieved.[10,16,20,52,63]

Skeletal width in BB appliances was only evaluated in the Koudstaal et al. 2009[11] study, with a mean nasal floor relapse of 41.6% and a mean maxillary level relapse of 16%, founding no significant differences compared to the TB appliances. However, the increased differences of the maxillary width at the upper level (nasal floor) and the caudal level (maxillary level) were significant for the total expansion changes (skeletal treatment changes) and the changes of width relapse within the TB and BB groups, being greater in the TB group[11]. This made a pattern of greater width relapse going from the top (nasal floor) to the bottom (maxilla level) along the vertical axis in the maxilla, suggesting that lesser rigidity and greater distances of the distraction appliances from the center of

resistance achieved greater width relapses. It is also important to notice that greater skeletal expansions were achieved at more caudal levels, in contrast lesser width expansions were seen in the nasal floor (upper level)[10,16,47] for both TB and BB appliances.

In general, the outcomes of dental width stability in the literature were consistent with presenting lesser relapse percentages in BB groups than in the TB groups for the canine, premolar and molar regions.[10,16,17,20,50,63] However, when analyzing studies that compared TB and BB appliances, significant differences were not encountered[10]. Within studies with greater canine relapses compared to the molar regions, retention periods seem to have an important role, because arc-form coordination and post-operative adjustments made evident a pseudo dental relapse[20,52]. Another reason is that patients with indication for SARME procedures, regularly have canines in an infra-labioversion position, these teeth tend to be aligned in the arc-form during the post-operative period and therefore taking a more lingual position[50].

Both appliances offered a good long-term stability, ranking high in the hierarchy of stability[47,66] in accordance with SARPE procedures. It is important to mention that the greatest skeletal relapses were encountered in the nasal floor followed by the upper maxilla, being very similar for both TB and BB appliances. Subsequently, this coincides with the maxillary outward pattern of expansion reported in the studies[10,52] for TB and BB appliances, showing that the increase in segmental maxillary tipping during the retention period, in conjunction with the small amount of relapse in TB and BB groups, does not influence relapse in SARME procedures. [10]

Surgical complications were also analyzed in this systematic review. A total of 399 patients comprehended the sample of studies that evaluated this outcome[1,10,15,55,57–63], in which 56.6% of the patients had tooth-borne appliances and 43.4% used bone-borne appliances. Overall, 267 patients reported some complication. A 68.5% of the patients within the TB group and 64.7% of the BB group reported some complications, for a whole number of 267 patients.

For better analysis of data, it was divided in six types of complications: I. Dentoalveolar, II. Skeletal, III. Hemorrhage related, IV. Nerve related V. Appliance-related VI. Others. Therefore, each complication reported was grouped according each type. For TB appliances the most prevalent complication encountered was bone resorption (dentoalveolar), followed by loss of attachment/gingival recession, then pain and nasal bleeding.[10,15,59,62] Since TB appliances have direct effects on dentoalveolar tissues, it seems more obvious that the most prevalent complications affect the periodontium. Gauthier 2011 et al[59] studied the periodontal effects on SARME/SARPE procedures with a TB appliance used, founding some statistically significant changes at follow-up periods of 6 months when evaluated radiographically. Other studies reported a high prevalence of bone resorption on TB and BB appliances[58], founding the biggest vestibular bone resorptions in patients with TB appliances who were submitted to SARME without PMD and that were over 20 years old. This findings relate to the fact that perhaps in TB appliances, the periodontium of the anchoraged teeth are directly damaged.[58,62,63] The highest prevalence of appliance-related complications were encountered in 18% of the sample of BB patients, followed by bone resorption in 13.87%.[55–58]. As dictates the surgical technique for BB distraction[67], additional incisions are needed in the palatal vault

for insertion of the appliance, thus contemplating all the possible post-operative complications derived from the utilization of osteosynthesis screws and poor adaptation of the hardware[55–57]. In addition, Laudemann et al. 2010[60], pointed that the periodontal complications derived from BB appliances take place for greater forces transmitted to the palatal halves, thus at the price of bigger overall attachment loss.

In general, care must be taken in the pre-operative evaluations when performing expansion procedures to ensure that good attached gingiva remains mainly in the anchorage teeth or the ones near the different osteotomies in SARME[56]. The lack of anchorage teeth could beneficiate the choice for BB appliances, but no significant differences were reported in studies for the complications in terms of jeopardizing the SARME procedures.[10,56,58,60,62,63]

The methodological quality criteria of the articles included in the present study was used by previous systematic reviews[12,70]. Therefore, only randomized clinical trial with outcome assessor blinding, being one article meeting this criteria[54]. Only 3 articles met the medium risk of bias criteria[10,58,60], in which two[58,60] not included sample randomization and one of them not blind assessed the outcome.[10] The rest 19 articles included in this systematic review[1,13–18,20,50–53,55–57,59,61–63] had a high risk of bias. The articles that presented stability/complications[1,10,13–18,20,50–54,63] as an outcome were more robust compared to the ones that reported only complications[55–62]. Therefore, a meta-analyses could not be performed due to the heterogeneity of the variables encountered in the two randomized clinical trials of stability[10,54], since one of them compared TB vs BB appliances and the other one TB vs HB appliances. However, through a search strategy where encompasses the literature regarding relapse/stability and complications in TB and

BB/HB appliances, this systematic review was able to analyze the outcomes of the 23 articles included[1,10,13–18,20,50–63]. To the authors' knowledge, there is one systematic review[72] that evaluated relapse of TB and BB appliances, nevertheless the authors included in the final revision a RCT[37] that as the proper author reported, one of their limitations was not assessing relapse and long-term stability. In order to review the majority of literature reporting relapse associated with TB and BB appliances, the authors in the present study did not limit the inclusion for study design, thus embracing original and interventional studies with prospective and retrospective designs.

According to the results of this systematic review, the outcomes of TB and BB appliances provide excellent stability in SARME procedures. However, in general greater dental width relapses were encountered for TB appliances. There is a consensus that initial anterior gap aperture must be obtained in order to better guarantee an eventual maxillary expansion[10,20,52]. The different variables on the studies of the TB and BB appliances, regarding expansion protocols, surgical technique variations, patients' age must be considered for treatment planification and clinical decision-making. It is imperative the articulated and interdisciplinary work with the orthodontist, as SARME/SARPE is a procedure that involves both parties. Regarding to relapse in TB and BB appliances, it is observed that many dental movements are made during the retention period, where can varied from 3-6 months, founding relapse measurements mainly due post-orthodontic movements with the purpose of the correction of overexpansion, arch-form coordination and final vertical adjustments[10,17,47]. Thus, long-term stability after SARME/SARPE will depend also on the orthodontist ability to obtain a stable and functional occlusion[52].

According to the quality of evidence of the studies reviewed, it is imperative the evaluation through RCT. As it is demonstrated to be the best and a very suitable study design for SARME, RCT are ideal for the evaluation of skeletal and dental relapse, thus generating the best scientific literature and proportionating more homogeneous data that could derived in the elaboration of meta-analysis studies.

# III Considerações finais

Através da análise dos resultados presentes na literatura, sugere-se que os dispositivos TB e BB apresentaram uma estabilidade excelente em procedimentos de SARME/SARPE. As maiores recidivas dentárias foram reportadas em aparelhos ou dispositivos de ancoragem dentária (TB), não havendo diferenças estatisticamente significativas quando comparados os dois dispositivos de TB e BB.

Em geral, a região canina apresentou menores recidivas de largura comparada com a região molar da maxila em aparelhos TB, devido à força aplicada sobre os pilares (molares) durante a expansão, criando um efeito de “tipping” dos dentes ancorados. Porém, quando as recidivas da região canina foram maiores, um raciocínio plausível atribui-se à coordenação dos caninos no arco dentário durante o período de consolidação, assim como ao estabelecimento das relações anteroposteriores e verticais dos pacientes, levando-os a uma possível pseudo-recidiva. Notou-se que uma maior expansão durante os câmbios de tratamento leva a maiores recidivas, não havendo sido encontradas diferenças significativas para dita associação.

As recidivas de largura dos aparelhos BB tiveram percentagens menores e mais similares entre si, significando que os vetores de força exercidos através dos segmentos hemi-maxilares poderiam percorrer mais homogeneamente, portanto expandindo a maxila em corpo, mas não houve neste aspecto diferenças significativas nos estudos que compararam os aparelhos TB e BB. O anterior poderia encontrar-se em estreita associação à localização ou direção do parafuso e dispositivo de expansão, à técnica cirúrgica empregada e à idade dos e das pacientes.

Em relação à recidiva esquelética dos aparelhos TB e BB, encontrou-se maiores recidivas no assoalho nasal comparada às recidivas ao nível da maxila, sem encontrar diferenças significativas em ambos grupos de aparelhos TB e BB quando comparados. Estabeleceu-se um padrão de expansão da maxila em sentido para fora ou divergente da linha média em sentido coronal visto em ambos grupos de dispositivos.

Os protocolos de expansão de 0.5-1mm de taxa de apertura por dia, períodos de latência de 1-7 dias e períodos de consolidação de 3-6 meses, foram maiormente reportados na literatura apresentando êxito nos tratamentos, tanto para aparelhos TB quanto BB.

Os aparelhos TB e BB apresentaram maior prevalência de complicações dentoalveolares. Nos aparelhos TB, foram encontrados mais prevalentes a reabsorção óssea, perda de inserção e recessão gengival, dor e sangramento nasal. Enquanto aos aparelhos BB, as complicações associadas aos dispositivos em si, as complicações dentoalveolares e assimetrias de expansão foram as mais prevalentes.

Enquanto à qualidade de evidencia cientifica é baixa, sendo que há estudos com qualidade maiores porem muito escassos, portanto não possibilitando à comparação de estudos com níveis semelhantes de qualidade cientifica. Faz-se necessária a elaboração de ensaios clínicos randomizados bem delineados com controles a longo prazo para que possa-se dizer qual ancoragem dentária ou esquelética em expansão rápida da maxila cirurgicamente assistida apresenta maior estabilidade.

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**Apêndice 1.**

**Ficha de Elegibilidade**

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**Study:** *blinded study number* **Reviewer:** *reviewer name*

**Does the study is about TB, BB or HB appliances in SARME/SARPE?**

**Yes** **Doubtful** **No**

⇩ ⇩ ⇩

Continue Continue Exclude

**Does the study evaluate stability and/or complications with TB, BB or HB appliances?**

**Yes** **Doubtful** **No**

⇩ ⇩ ⇩

Continue Continue Exclude

**Does the study is an interventional one?**

**Yes** **Doubtful** **No**

⇩ ⇩ ⇩

Continue Continue Exclude

**Does the study present skeletal/dental relapse measurements and/or complication rates regarding TB, BB or HB appliances?**

**Yes** **Doubtful** **No**

⇩ ⇩ ⇩

Continue Continue Exclude

**Does the study is original?**

**Yes** **Doubtful** **No**

⇩ ⇩ ⇩

Continue Continue Exclude

**FINAL DECISION**

☐ **Inlcude**

☐ **Doubtful** (Discuss with experienced reviewers)

☐ **Exclude** (Do not complete the following pages)

**Anexo 1. Cópia da aprovação do projeto de pesquisa pela Comissão Cientifica e de Ética da Escola de Odontologia da Faculdade de Ciências da Sáude da PUCRS.**

Pontifícia Universidade Católica do Rio Grande do Sul
FACULDADE DE ODONTOLOGIA
PÓS-GRADUAÇÃO

**PROGRAMA DE PÓS-GRADUAÇÃO EM ODONTOLOGIA**
**ÁREA DE CONCENTRAÇÃO: CTBMF**
**NÍVEL: MESTRADO**
**EXAME DE QUALIFICAÇÃO – ATA 24/17**

Data: 14/11/2017 Horário: 11h

Aluno: Mauricio Esteban Muñoz Pereira

Orientador: Prof. Dr. Rogério Miranda Pagnoncelli

Título da pesquisa: "Estabilidade e complicações da ancoragem esquelética, dentária e híbrida na expansão rápida de maxila assistida cirurgicamente: revisão sistemática/metanálise".

Comissão Examinadora: Profa. Dra. Maria Ivete Bolzan Rockenbach (PUCRS)
Prof. Dr. Rogério Belle de Oliveira (PUCRS)

(X) Aprovado

( ) Aprovado com projeto pendente

( ) Reprovado

Ass.: _____
**Mauricio Esteban Muñoz Pereira**
**Aluno**

Ass.: _____
**Prof. Dr. Rogério Miranda Pagnoncelli**
**Orientador**

Ass.: _____
**Profa. Dra. Maria Ivete Bolzan Rockenbach**
**Professora Avaliadora**

Ass.: _____
**Prof. Dr. Rogério Belle de Oliveira**
**Professor Avaliador**

Ass.: _____
**Profa. Dra. Maria Martha Campos**
**Coordenadora do Programa de Pós-Graduação em Odontologia**

## ANEXO 2. CARTA SIPESQ

PUCRS

# SIPESQ

Sistema de Pesquisas da PUCRS

Código SIPESQ: 8446

Porto Alegre, 12 de dezembro de 2017.

Prezado(a) Pesquisador(a),

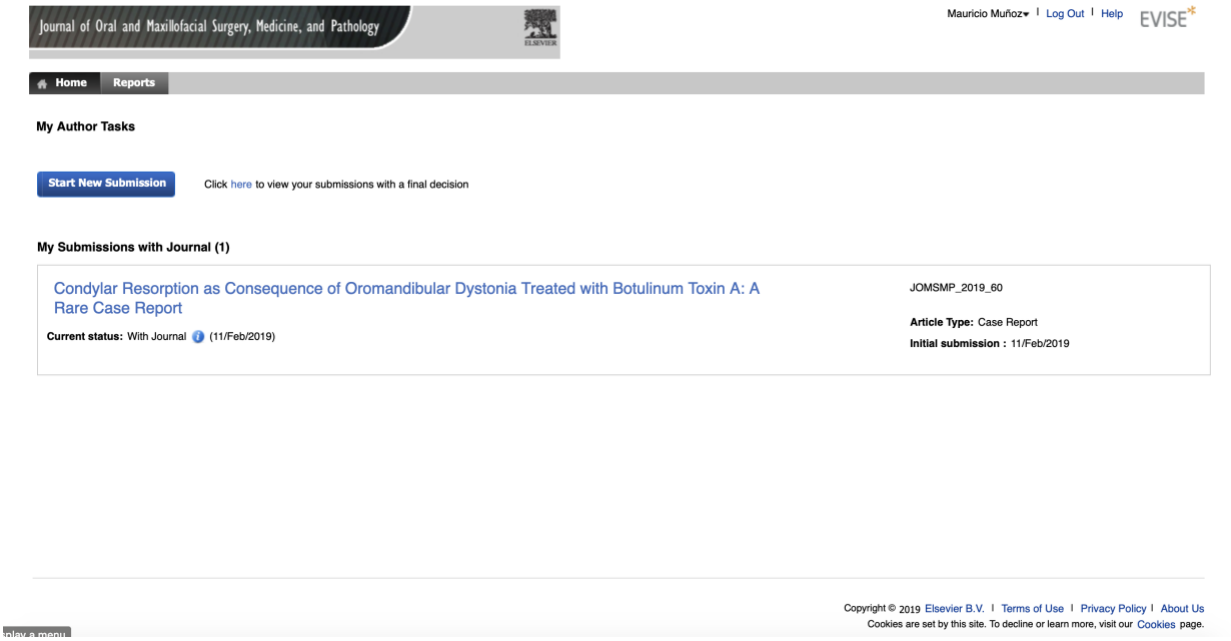
A Comissão Científica da FACULDADE DE ODONTOLOGIA da PUCRS apreciou e aprovou o Projeto de Pesquisa "Estabilidade e complicações da ancoragem dentária, esquelética e híbrida na expansão rápida de maxila assistida cirurgicamente: revisão sistemática/metanálise".

Atenciosamente,

Comissão Científica da FACULDADE DE ODONTOLOGIA

# Anexo 3.

(colocar email de submissão do artigo 2)

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